4.2 Surface Water and Sediment Surveillance

G. W. Patton

Samples of surface water and sediment on and near the Hanford Site are collected and analyzed to determine the potential impact to the public and to the aquatic environment from Hanford-originated radiological and chemical contaminants. Surface-water bodies included in routine surveillance are the Columbia River and associated riverbank springs, onsite ponds, and an offsite irrigation canal. Sediment surveillance is conducted for the Columbia River and riverbank springs. Tables 4.2.1 and 4.2.2 summarize the sampling locations, types, frequencies, and analyses included in surface water and sediment surveillance activities during 1999. Sampling locations are identified in Figure 4.2.1. This section describes the surveillance effort and summarizes the results for these aquatic environments. Detailed analytical results are reported in PNNL-13230, APP. 1.

4.2.1 Columbia River Water

The Columbia River is the second largest river in the continental United States in terms of total flow and is the dominant surface-water body on the Hanford Site. The original selection of the Hanford Site for plutonium production and processing was, in part, on the abundant water supply offered by the river. The river flows through the northern edge of the site and forms part of the site's eastern boundary. The river is used as a source of drinking water for onsite facilities and communities located downstream from the Hanford Site. Water from the river downstream of the site is also used for crop irrigation. In addition, the Hanford Reach of the Columbia River is used for a variety of recreational activities, including hunting, fishing, boating, water-skiing, and swimming.

Originating in the mountains of eastern British Columbia, the Columbia River drains an area of ~670,000 square kilometers (260,000 square miles) en route to the Pacific Ocean. The flow of the river is regulated by three dams in Canada and eleven dams in the United States, seven upstream and four downstream of the site. Priest Rapids Dam is the nearest upstream dam and McNary Dam is the nearest downstream dam from the site. The Hanford Reach of the Columbia River extends from Priest Rapids Dam to the head of Lake Wallula (created by McNary Dam) near Richland, Washington. The Hanford Reach is the last stretch of the Columbia River in the United States above Bonneville Dam that remains unimpounded.

River flow through the Hanford Reach fluctuates significantly and is controlled primarily by operations at Priest Rapids Dam. Annual average flows of the Columbia River below Priest Rapids Dam are nearly 3,400 m^3 (120,000 ft^3) per second (WA-94-1). In 1999, the Columbia River had higher than normal flows; the average daily flow rate below Priest Rapids Dam was 4,110 m^3 (145,000 ft^3) per second. The peak monthly average flow rate occurred during June (5410 m^3 [191,000 ft^3] per second) (Figure 4.2.2). The lowest monthly average flow rate occurred during October (2,670 m^3 [94,400 ft^3] per second). Daily flow rates varied from 1,480 to 6,370 m^3 (52,400 to 225,000 ft^3) per second during 1999. As a result of fluctuations in discharges, the depth of the river

Table 4.2.1. Surface-Water Surveillance, 1999

Location	Sample Type	Frequency[a]	Analyses
Columbia River - Radiological			
Priest Rapids Dam and Richland Pumphouse	Cumulative	M Comp[b] Q Comp[e]	Alpha, beta, lo ^{3}H,[c] ^{90}Sr, ^{99}Tc, U[d] ^{129}I
	Particulate (filter)	M Cont[f] Q Cont[g]	Gamma scan Pu[h]
	Soluble (resin)	M Cont Q Cont	Gamma scan Pu
Vernita Bridge and Richland Pumphouse	Grab (transects)	Q	lo ^{3}H, ^{90}Sr, U
100-F, 100-N, 300, and Old Hanford Townsite	Grab (transects)	A	lo ^{3}H, ^{90}Sr, U
Columbia River - Nonradiological			
Vernita Bridge and Richland Pumphouse[i]	Grab	Q	NASQAN, temperature, dissolved oxygen, turbidity, pH, alkalinity, anions, suspended solids, dissolved solids, specific conductance, hardness (as $CaCO_3$), Ca, P, Cr, Mg, N-Kjeldahl, Fe, NH_3, NO_3 + NO_2
	Grab (transects)	Q	ICP[j] metals, anions
	Grab (transects)	A	Cyanide (CN^-), VOA[k]
100-F, 100-N, 300, and Old Hanford Townsite	Grab (transects)	A	ICP metals, anions
Onsite Ponds			
West Lake	Grab	Q	Alpha, beta, ^{3}H, ^{90}Sr, ^{99}Tc, U, gamma scan
Fast Flux Test Facility pond	Grab	Q	Alpha, beta, ^{3}H, gamma scan
Offsite Water			
Riverview irrigation canal	Grab	3/year	Alpha, beta, ^{3}H, ^{90}Sr, U, gamma scan
Riverbank Springs			
100-H Area	Grab	A	Alpha, beta, ^{3}H, ^{90}Sr, ^{99}Tc, U, gamma scan, ICP metals, anions
100-F Area	Grab	A	Alpha, beta, ^{3}H, ^{90}Sr, U, gamma scan, ICP metals, anions, VOA
100-B Area	Grab	A	Alpha, beta, ^{3}H, ^{90}Sr, ^{99}Tc, gamma scan, ICP metals, anions
100-D, 100-K, and 100-N Areas	Grab	A	Alpha, beta, ^{3}H, ^{90}Sr, gamma scan, ICP metals, anions, VOA (100-K Area only)
Old Hanford Townsite and 300 Area	Grab	A	Alpha, beta, ^{3}H, ^{129}I, ^{90}Sr, ^{99}Tc, U, gamma scan, ICP metals, anions, VOA (300 Area only)

(a) A = Annually; M = Monthly; Q = Quarterly; Comp = Composite.
(b) M Comp indicates river water was collected hourly and composited monthly for analysis.
(c) lo ^{3}H = Low-level tritium analysis (10-pCi/L detection limit), which includes an electrolytic preconcentration.
(d) U = Isotopic uranium-234, -235, and -238.
(e) Collected weekly and composited for quarterly analysis.
(f) M Cont = River water was sampled for 2 wk by continuous flow through a filter and resin column and multiple samples were composited monthly for analysis.
(g) Q Cont = River water was sampled for 2 wk by continuous flow through a filter and resin column and multiple samples were composited quarterly for analysis.
(h) Pu = Isotopic plutonium-238 and -239/240.
(i) Numerous water quality analyses are performed by the U.S. Geological Survey in conjunction with the National Stream Quality Accounting Network (NASQAN) Program.
(j) ICP = Inductively coupled plasma analysis method.
(k) VOA = Volatile organic compounds.

Table 4.2.2. Sediment Surveillance, 1999

Location[a]	Frequency	Analyses
River		All river sediment analyses included gamma scan, ^{90}Sr, U[b], Pu[c], ICP[d] metals, SEM/AVS[e]
Priest Rapids Dam: 4 equally spaced (approximate) stations on a transect from the Grant County shore to the Yakima County shore 2 locations near the dam	A[f]	
White Bluffs Slough	A	
100-F Slough	A	
Hanford Slough	A	
Richland	A	
McNary Dam: 4 equally spaced (approximate) stations on a transect from the Oregon shore to the Washington shore 2 locations near the dam	A	
Ice Harbor Dam 3 equally spaced (approximate) stations on a transect from the Walla Walla County shore to the Franklin County shore	A	
Springs[g]		All springs sediment analyses included gamma scan, ^{90}Sr, U, ICP metals
100-B Area	A	
100-K Area	A	
100-N Area	A	
100-F Area	A	
Old Hanford Townsite Springs	A	
300 Area	A	

(a) See Figure 4.2.1.
(b) U = Uranium-235 and -238 analyzed by low-energy photon analysis.
(c) Pu = Isotopic plutonium-238 and -239/240.
(d) ICP = Inductively coupled plasma analysis method.
(e) SEM/AVS = Simultaneously extracted metals and acid volatile sulfide.
(f) A = Annually.
(g) Sediment is collected when available.

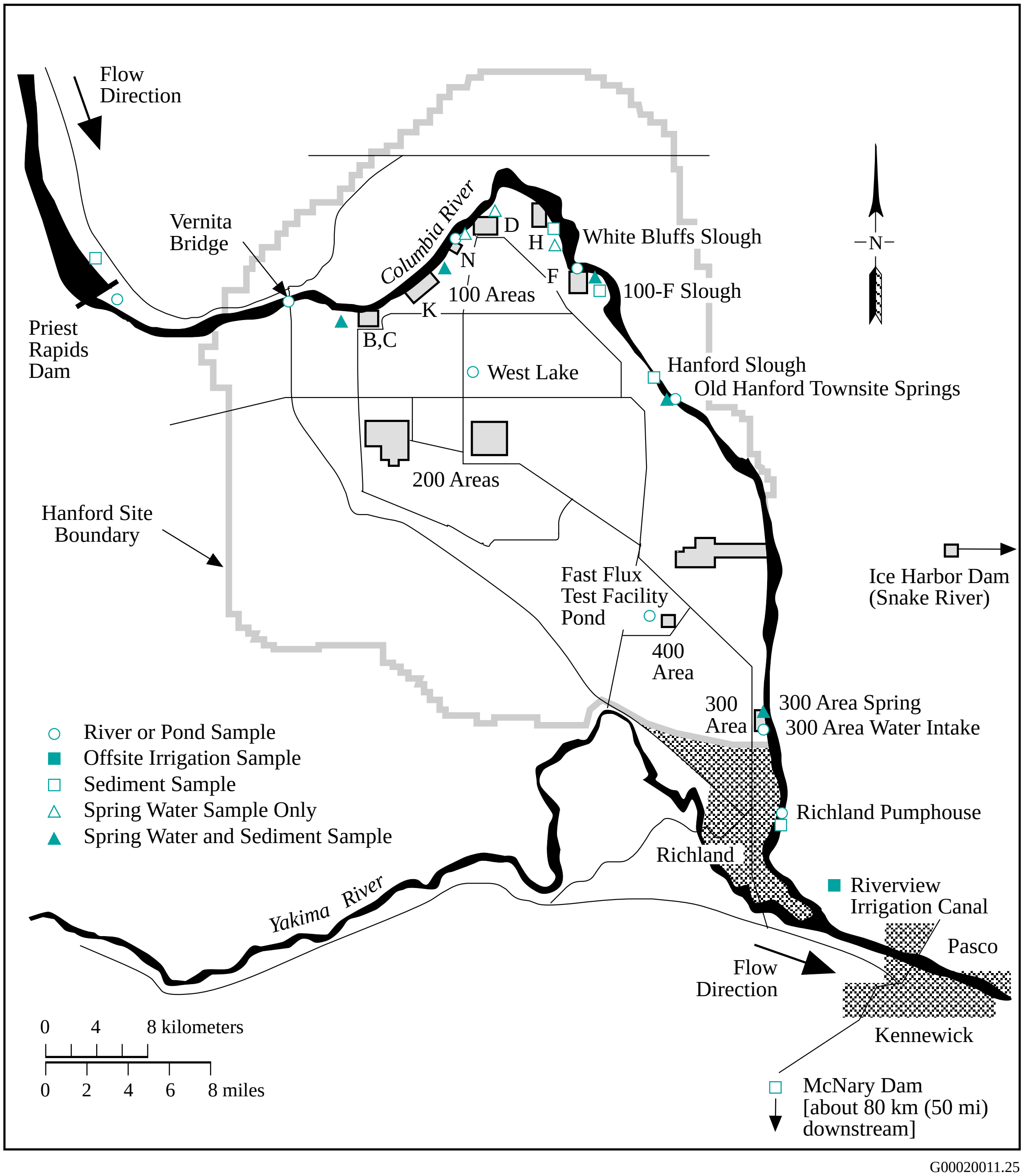

Figure 4.2.1. Water and Sediment Sampling Locations, 1999

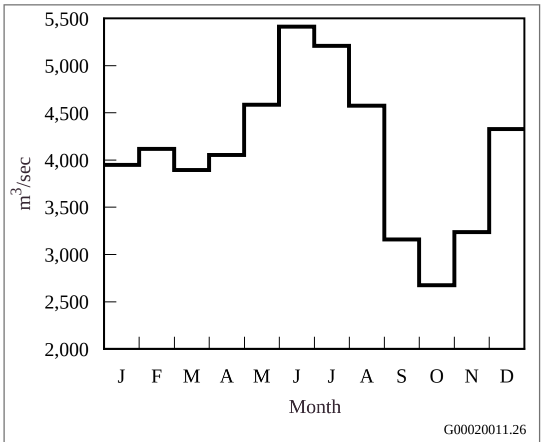

Figure 4.2.2. Mean Monthly Columbia River Flow Rates, 1999

varies significantly over time. River stage (surface level) may change along the Hanford Reach by up to 3 meters (10 feet) within a few hours (Section 3.3.7 in PNL-10698). Seasonal changes of approximately the same magnitude are also observed. River-stage fluctuations measured at the 300 Area are approximately half the magnitude of those measured near the 100 Areas because of the effect of the pool behind McNary Dam (PNL-8580) and the relative distance of each area from Priest Rapids Dam. The width of the river varies from approximately 300 to 1,000 meters (980 to 3,300 feet) through the Hanford Site.

Pollutants, both radiological and nonradiological, are known to enter the Columbia River along the Hanford Reach. In addition to permitted direct discharges of liquid effluents from Hanford facilities, contaminants in groundwater from past operational discharges to the ground are known to seep into the river (DOE/RL-92-12, PNL-5289, PNL-7500, WHC-SD-EN-TI-006). Effluents from each direct discharge point are monitored routinely and reported by the responsible operating contractor; these were summarized in Section 3.1, "Facility Effluent Monitoring." Direct discharges are identified and regulated for nonradiological constituents under the National Pollutant Discharge Elimination System in compliance with the *Clean Water Act*. The National Pollutant Discharge Elimination System-permitted discharges at the Hanford Site are summarized in Section 2.2.8, "Clean Water Act."

Washington State has classified the stretch of the Columbia River from Grand Coulee Dam to the Washington-Oregon border, which includes the Hanford Reach, as Class A, Excellent (WAC 173-201A). Water quality criteria and water use guidelines have been established in conjunction with this designation and are provided in Appendix C (Table C.1).

4.2.1.1 Collection of River-Water Samples and Analytes of Interest

Samples of Columbia River water were collected throughout 1999 at the locations shown in Figure 4.2.1. Samples were collected from fixed-location monitoring stations at Priest Rapids Dam and the Richland Pumphouse and from Columbia River transects and near-shore locations near the Vernita Bridge, 100-F Area, 100-N Area, Old Hanford Townsite, 300 Area, and Richland Pumphouse. Samples were collected upstream from Hanford Site facilities at Priest Rapids Dam and Vernita Bridge to provide background data from locations unaffected by site operations. Samples were collected from all other locations to identify any increase in contaminant concentrations attributable to Hanford operations. The Richland Pumphouse is the first downstream point of Columbia River water withdrawal for a municipal drinking water supply.

The fixed-location monitoring stations at Priest Rapids Dam and the Richland Pumphouse consisted of both an automated sampler and a continuous flow system. Using the automated sampler, unfiltered samples of Columbia River water (cumulative samples) were obtained hourly and collected weekly. Weekly samples were composited monthly for radiological analyses (see Table 4.2.1). Using the continuous flow system, particulate and soluble fractions of selected Columbia River water constituents were collected by passing water through a filter and then through a resin column. Filter and resin samples were exchanged approximately every 14 days and were combined into quarterly composite samples for radiological analyses. The river sampling locations and the methods used for sample collection are discussed in detail in DOE/RL-91-50, Rev. 2.

Radionuclides of interest were selected for analysis based on

- their presence in effluents discharged from site facilities or in near-shore groundwater underlying the Hanford Site
- their importance in determining water quality, verifying effluent control and monitoring systems, and determining compliance with applicable standards.

Analytes of interest in water samples collected from Priest Rapids Dam and the Richland Pumphouse included gross alpha, gross beta, selected gamma emitters, tritium, strontium-90, technetium-99, iodine-129, uranium-234, -235, -238, plutonium-238, and plutonium-239/240. Gross alpha and beta measurements are indicators of the general radiological quality of the river and provide a timely indication of change. Gamma scans provide the ability to detect numerous specific radionuclides (see Appendix E). Sensitive radiochemical analyses were used to determine the concentrations of tritium, strontium-90, technetium-99, iodine-129, uranium-234, -235, -238, plutonium-238, and plutonium-239/240 in river water during the year. Analytical detection levels for all radionuclides were less than 10% of their respective water quality criteria levels (see Appendix C, Table C.2).

Transect sampling was initiated as a result of findings of a special study conducted during 1987 and 1988 (PNL-8531). That study concluded that, under certain flow conditions, contaminants entering the river from the Hanford Site are not completely mixed when sampled at routine monitoring stations located downriver. Incomplete mixing results in a slightly conservative (high) bias in the data generated using the routine, single-point, sampling system at the Richland Pumphouse. For 1999, the transect sampling strategy was modified, with some of the mid-river sampling points shifted to near-shore locations in the vicinity of the transect. For example, at the 100-N Area instead of collecting ten evenly-spaced cross-river transect samples, only six cross-river samples were collected and the other four samples were obtained at near-shore locations. This sampling pattern allows the cross-river concentration profile to be determined and provides information over a larger portion of the Hanford shoreline where the highest contaminant concentrations would be expected. The Vernita Bridge and the Richland Pumphouse transects and near-shore locations were sampled quarterly during 1999. Annual transect and near-shore sampling was conducted at the 100-F Area, 100-N Area, Old Hanford Townsite, and 300 Area locations in the late summer during low flow.

Columbia River transect water samples collected in 1999 were analyzed for both radiological and chemical contaminants (see Table 4.2.1). Metals and anions (listed in DOE/RL-93-94, Rev. 1) were selected for analysis following reviews of existing surface-water and groundwater data, various remedial investigation/feasibility study work plans, and preliminary Hanford Site risk assessments (DOE/RL-92-67, PNL-8073, PNL-8654, PNL-10400, PNL-10535). All radiological and chemical analyses of transect samples were performed on unfiltered water, except for metals analyses which were performed on both filtered and unfiltered samples.

In addition to Columbia River monitoring conducted by Pacific Northwest National Laboratory in 1999, nonradiological water quality monitoring was also performed by the U.S. Geological Survey in conjunction with the National Stream Quality Accounting Network program. U.S. Geological Survey samples were collected along Columbia River transects quarterly at the Vernita Bridge and the

Richland Pumphouse (Appendix A, Table A.5). Sample analyses were performed at the U.S. Geological Survey laboratory in Denver, Colorado for numerous physical and chemical constituents.

4.2.1.2 Radiological Results for River-Water Samples

Fixed Location Sampling. Results of the radiological analyses of Columbia River water samples collected at Priest Rapids Dam and Richland Pumphouse during 1999 are reported in PNNL-13230, APP. 1 and summarized in Appendix A (Tables A.1 and A.2). These tables also list the maximum and mean concentrations of selected radionuclides observed in Columbia River water in 1999 and during the previous 5 years. All radiological contaminant concentrations measured in Columbia River water in 1999 were less than DOE derived concentration guides (DOE Order 5400.5) and Washington State ambient surface-water quality criteria (WAC 173-201A and 40 CFR 141) levels (see Appendix C, Tables C.5, C.3, and C.2, respectively). Significant results are discussed and illustrated below, and comparisons to previous years are provided.

Radionuclide concentrations monitored in Columbia River water were extremely low throughout the year. The radionuclides consistently detected in river water during 1999 included tritium, strontium-90, iodine-129, uranium-234, -238, and plutonium-239/240. The concentrations of all other measured radionuclides were below detection limits in more than 75% of samples collected. Tritium, strontium-90, iodine-129, and plutonium-239/240 exist in worldwide fallout, as well as in effluents from Hanford facilities. Tritium and uranium occur naturally in the environment, in addition to being present in Hanford Site effluents.

Figures 4.2.3 and 4.2.4 illustrate the average annual gross alpha and gross beta concentrations, respectively, at Priest Rapids Dam and Richland

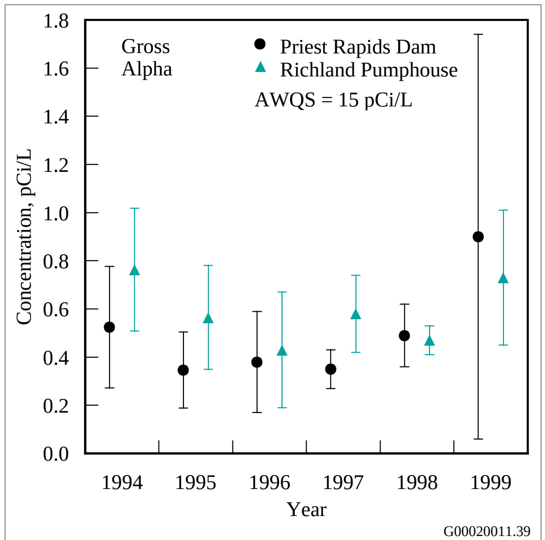

Figure 4.2.3. Annual Average Gross Alpha Concentrations (±2 standard error of the mean) in Columbia River Water, 1994 Through 1999 (AWQS = ambient water quality standard)

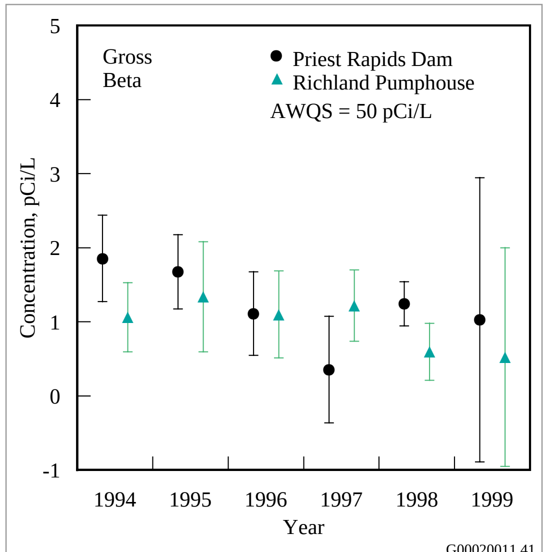

Figure 4.2.4. Annual Average Gross Beta Concentrations (±2 standard error of the mean) in Columbia River Water, 1994 Through 1999 (AWQS = ambient water quality standard)

Pumphouse during the past 6 years. The 1999 average gross alpha and gross beta concentrations were similar to those observed during recent years. Monthly measurements at the Richland Pumphouse in 1999 were not statistically different (unless otherwise noted in this section, the statistical tests for difference are paired sample comparison and two-tailed t-test, 5% significance level) from those measured at Priest Rapids Dam. The average alpha and beta concentrations in Columbia River water at the Richland Pumphouse in 1999 were less than the ambient surface-water quality criteria levels of 15 and 50 pCi/L, respectively.

Figure 4.2.5 compares the annual average tritium concentrations at Priest Rapids Dam and Richland Pumphouse from 1994 through 1999. Statistical analysis indicated that monthly tritium concentrations in river water samples at the Richland Pumphouse were higher than samples at Priest Rapids Dam. However, 1999 average tritium concentrations in Columbia River water collected at the Richland Pumphouse were only 0.4% of the ambient surface-water quality criteria level of 20,000 pCi/L. Onsite sources of tritium entering the river include groundwater seepage and direct discharge from outfalls located in the 100 Areas (see Section 3.1, "Facility Effluent Monitoring," and Section 6.1, "Hanford Groundwater Monitoring Project"). Tritium concentrations measured at the Richland Pumphouse, while representative of river water used by the city of Richland for drinking water, tend to overestimate the average tritium concentrations across the river at this location (PNL-8531). This bias is attributable to the contaminated 200 Areas' groundwater plume entering the river along the portion of shoreline extending from the Old Hanford Townsite to below the 300 Area, which is relatively close to the Richland Pumphouse sample intake. This plume is not completely mixed within the river at the Richland Pumphouse. Sampling along cross-river transects at the pumphouse during 1999 confirmed the existence of a concentration gradient in the river under certain flow conditions and is discussed subsequently in this section. The extent to which samples taken from the Richland Pumphouse overestimate the average tritium concentrations in the Columbia River at this location is highly variable and appears to be related to the flow rate of the river just before and during sample collection.

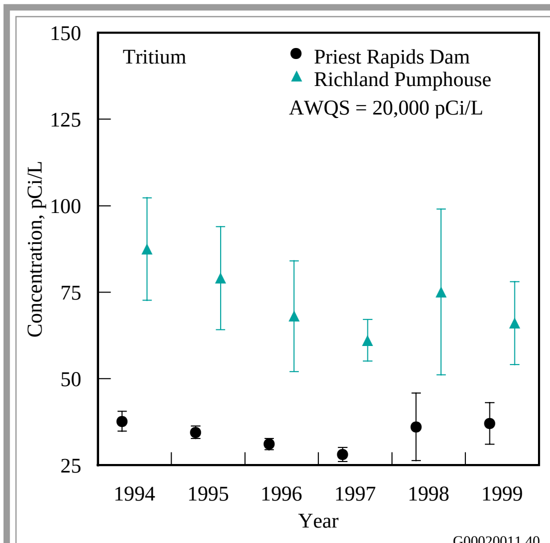

Figure 4.2.5. Annual Average Tritium Concentrations (±2 standard error of the mean) in Columbia River Water, 1994 Through 1999 (AWQS = ambient water quality standard)

The annual average strontium-90 concentrations in Columbia River water collected from Priest Rapids Dam and Richland Pumphouse from 1994 through 1999 are presented in Figure 4.2.6. Levels observed in 1999 were similar to those reported previously. Groundwater plumes containing strontium-90 enter the Columbia River throughout the 100 Areas (see Section 6.1.6.1, "Radiological Monitoring Results for the Unconfined Aquifer"). The highest strontium-90 levels that have been found in onsite groundwater are the result of past discharges to the 100-N Area liquid waste disposal facilities. Despite the Hanford Site source, the differences between monthly strontium-90 concentrations at Priest Rapids Dam and Richland Pumphouse in 1999 were not statistically different. Average

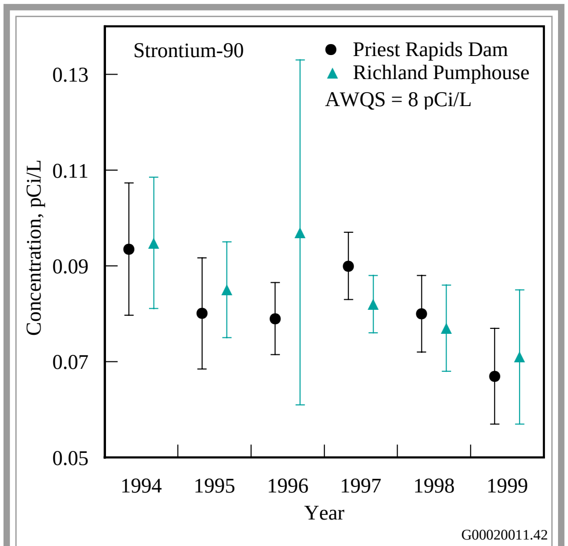

Figure 4.2.6. Annual Average Strontium-90 Concentrations (±2 standard error of the mean) in Columbia River Water, 1994 Through 1999 (AWQS = ambient water quality standard)

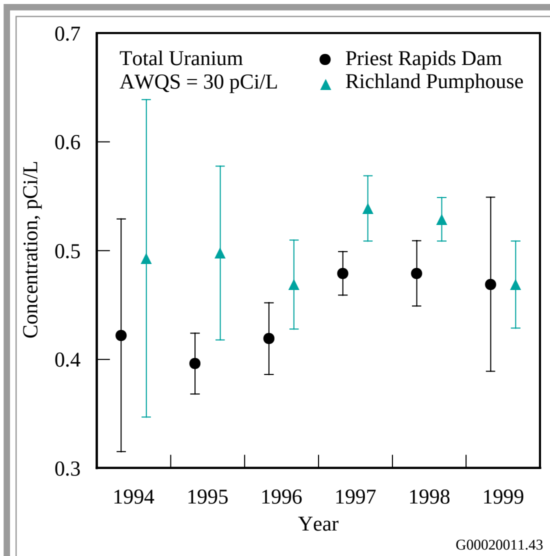

Figure 4.2.7. Annual Average Total Uranium Concentrations (±2 standard error of the mean) in Columbia River Water, 1994 Through 1999 (AWQS = ambient water quality standard)

strontium-90 concentrations in Columbia River water at the Richland Pumphouse were less than 1% of the 8-pCi/L ambient surface-water quality criteria level.

Annual average total uranium concentrations (i.e., the sum of uranium-234, -235, -238) at Priest Rapids Dam and Richland Pumphouse for 1994 through 1999 are shown in Figure 4.2.7. The large error associated with 1994 results was attributed to an unusually low concentration found in the December sample at each location. Total uranium concentrations observed in 1999 were similar to those observed during recent years. Monthly total uranium concentrations measured at the Richland Pumphouse in 1999 were not statistically higher than those measured at Priest Rapids Dam. Although there is no direct discharge of uranium to the river, uranium is present in the groundwater beneath the 300 Area as a result of past Hanford operations (see Section 6.1, "Hanford Groundwater Monitoring Project") and has been detected at elevated levels in riverbank springs in this area (see Section 4.2.3, "Riverbank Spring Water"). Naturally occurring uranium is also known to enter the river across from the Hanford Site via irrigation return water and groundwater seepage associated with extensive irrigation north and east of the Columbia River (PNL-7500). There are no ambient surface-water quality criteria levels directly applicable to uranium. However, total uranium levels in the river during 1999 were well below the proposed U.S. Environmental Protection Agency (EPA) drinking water standard of 20 µg/L (13.4 pCi/L, Appendix C, Table C.2).

The annual average iodine-129 concentrations at Priest Rapids Dam and Richland Pumphouse for 1994 through 1999 are presented in Figure 4.2.8. Only one quarterly iodine-129 result was available for the Richland Pumphouse during 1995 because of construction activities at the structure. The average iodine-129 concentration in Columbia River water at the Richland Pumphouse was extremely low during 1999 (0.008% of the ambient surface-water quality criteria level of 1 pCi/L [1,000,000 aCi/L]) and similar to levels observed during recent years. The onsite source of iodine-129 to the Columbia River is the discharge of contaminated groundwater along

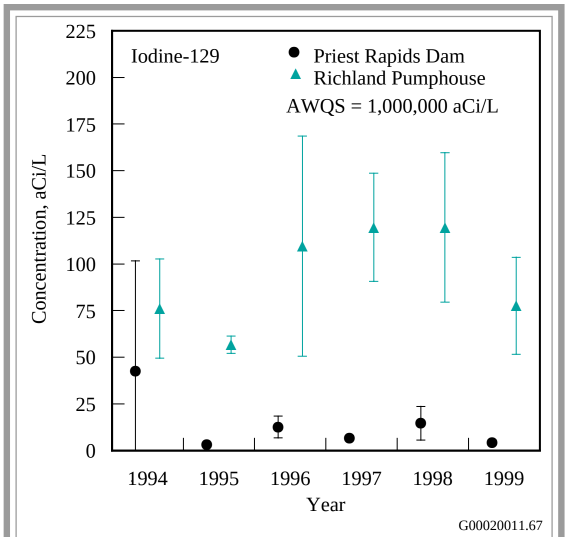

Figure 4.2.8. Annual Average Iodine-129 Concentrations (±2 standard error of the mean) in Columbia River Water, 1994 Through 1999 (AWQS = ambient water quality standard)

the portion of shoreline downstream of the Old Hanford Townsite (see Section 6.1, "Hanford Groundwater Monitoring Project"). The iodine-129 plume originated in the 200 Areas from past waste disposal practices. Quarterly iodine-129 concentrations in Columbia River water at the Richland Pumphouse were statistically higher than those at Priest Rapids Dam.

Plutonium-239/240 concentrations were at or near the detection limits for filter (particulate) and resin (dissolved) components for all samples. Average plutonium-239/240 concentrations on filter samples at Priest Rapids Dam and Richland Pumphouse were 23 ± 4.2 and 26 ± 24 aCi/L, respectively. With the exception of one sample at the Richland Pumphouse, plutonium was only detected for the particulate fraction of the continuous water sample (i.e., detected on the filters but not detected on the resin column). No ambient surface-water quality criteria levels exist for plutonium-239/240. However, if the DOE derived concentration guides (see Appendix C, Table C.5), which are based on a 100-mrem dose standard, are converted to the 4-mrem dose equivalent used to develop the drinking water standards and ambient surface-water quality criteria levels, 1,200,000 aCi/L would be the relevant guideline for plutonium-239/240. There was no statistical difference in plutonium-239/240 concentrations for filter samples at Priest Rapids Dam and Richland Pumphouse. Statistical tests for dissolved plutonium concentrations at Priest Rapids Dam and the Richland Pumphouse were not performed because the majority of the samples were below the detection limit.

River Transect and Near-Shore Sampling. Radiological results from samples collected along Columbia River transects and at near-shore locations near the Vernita Bridge, 100-F Area, 100-N Area, Old Hanford Townsite, 300 Area, and Richland Pumphouse during 1999 are presented in Appendix A (Tables A.3 and A.4) and PNNL-13230, APP. 1. Sampling locations were documented using a global positioning system. Constituents that were consistently detected at concentrations greater than two times their associated total propagated analytical uncertainty included tritium, strontium-90, uranium-234, and uranium-238. All measured concentrations of these radionuclides were less than applicable ambient surface-water quality criteria levels.

Tritium concentrations measured along Columbia River transects during September 1999 are depicted in Figure 4.2.9. The results are displayed such that the observer's view is upstream. Vernita Bridge is the most upstream transect. Stations 1 and 10 are located along the Benton County and Franklin/Grant Counties shorelines, respectively. The 100-N Area, Old Hanford Townsite, 300 Area, and Richland Pumphouse transects have higher tritium concentrations at the Hanford shore compared to the mid-river and opposite shore results. The presence of a tritium concentration gradient in the Columbia River at the Richland Pumphouse supports previous conclusions made in HW-73672 and PNL-8531 that contaminants in the 200 Areas' groundwater plume entering the river at, and

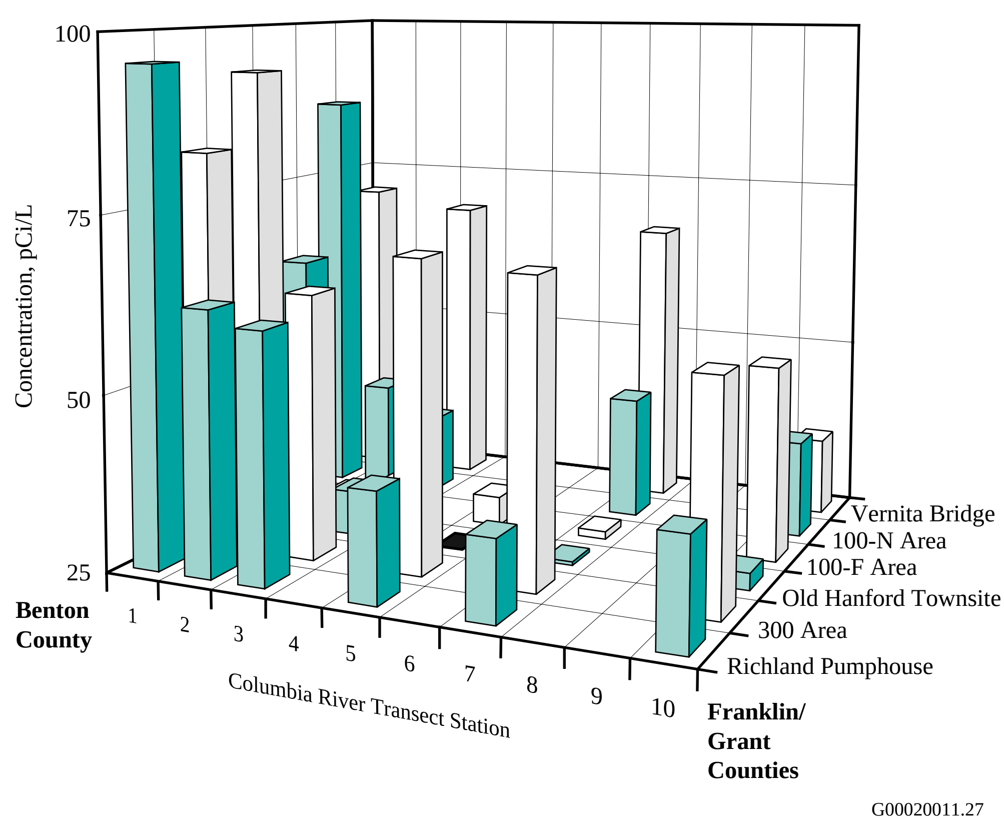

Figure 4.2.9. Tritium Concentrations in Water Samples from Columbia River Transects, September 1999

upstream of, the 300 Area are not completely mixed at the Richland Pumphouse. The gradient is most pronounced during periods of relatively low river flow. As noted since transect sampling was initiated in 1987, the mean tritium concentration measured along the Richland Pumphouse transect was less than that measured in monthly composited samples from the pumphouse, illustrating the conservative bias (i.e., overestimate) of the fixed-location monitoring station. The highest tritium concentration observed in 1999 near-shore water samples was 1,100 ± 95 pCi/L (see Table A.4), which was detected along the shoreline of the 300 Area. This is a location where groundwater containing tritium levels of over 2,000 pCi/L is known to discharge to the river (see Section 6.1.6.1, "Radiological Monitoring Results for the Unconfined Aquifer"). Slightly elevated levels of tritium were also evident near the Hanford Site shoreline at the 100-N Area, Old Hanford Townsite, and the Richland Pumphouse. The 1999 results for the Old Hanford Townsite ranged from 28 ± 6.0 to 51 ± 7.2 pCi/L, which were considerably below the 1998 result of 4,100 ± 350 pCi/L. It is not clear why the 1999 results are lower; however, mulberry tree samples and rooting zone samples collected in June also contained less tritium than expected from their proximity to the groundwater tritium plume (see Section 4.6.1, "Surveillance of Columbia River Shoreline Vegetation").

Strontium-90 concentrations in 1999 in both transect and near-shore samples were similar to background concentrations for all locations, except for the 100-N Area. The 100-N Area had elevated strontium-90 concentrations along all near-shore locations and the transect samples were elevated for only Hanford shoreline sample. The mean strontium-90 concentration found during transect sampling at the Richland Pumphouse was similar to that measured in monthly composite samples from the pumphouse; indicating that strontium-90 levels in water collected from the fixed-location monitoring station are representative of the average strontium-90 concentrations in the river at this location.

Total uranium concentrations in 1999 were elevated along the Franklin County shoreline of the 300 Area and Richland Pumphouse transects. The highest total uranium concentration was measured near the Franklin County shoreline of the 300 Area transect and likely resulted from groundwater seepage and water from irrigation return canals on the east side of the river that contained naturally occurring uranium (PNL-7500). The mean concentration of total uranium across the Richland Pumphouse transect was similar to that measured in monthly composited samples from the pumphouse.

4.2.1.3 Nonradiological Results for River-Water Samples

The U.S. Geological Survey and the Pacific Northwest National Laboratory compiled nonradiological water quality data during 1999. A number of the parameters measured have no regulatory limits; however, they are useful as indicators of water quality and contaminants of Hanford origin. Potential sources of pollutants not associated with Hanford include irrigation return water and groundwater seepage associated with extensive irrigation north and east of the Columbia River (PNL-7500).

U.S. Geological Survey. Figure 4.2.10 shows U.S. Geological Survey results for the Vernita Bridge and Richland Pumphouse for 1994 through 1999 (1999 results are preliminary) for several water quality parameters with respect to their applicable standards. The complete list of preliminary results obtained through the U.S. Geological Survey National Stream Quality Accounting Network program is documented in PNNL-13230, APP. 1 and is summarized in Appendix A (Table A.5). Final results are published annually by the U.S. Geological Survey (e.g., Wiggins et al. 1996). The 1999 U.S. Geological Survey results were comparable to those reported during the previous 5 years. Applicable standards for a Class A-designated surface-water body were met. During 1999, there was no indication of any deterioration of water quality resulting from site operations along the Hanford Reach of the Columbia River (see Appendix C, Table C.1).

River Transect and Near-Shore Samples. Results of nonradiological sampling conducted by Pacific Northwest National Laboratory along transect and near-shore locations of the Columbia River in 1999 at Vernita Bridge, 100-F Area, 100-N Area, Old Hanford Townsite, 300 Area, and Richland Pumphouse are provided in PNNL-13230, APP. 1. The concentrations of metals and anions observed in river water in 1999 were similar to those observed in the past. Several metals and anions were detected in Columbia River transect samples both upstream and downstream of the Hanford Site. Arsenic, antimony, cadmium, chromium, lead, nickel, thallium, and zinc were detected in the majority of samples, with similar levels at most locations. Beryllium, selenium, and silver were only occasionally detected. Nitrate concentrations were slightly elevated compared to mid-river samples for the Benton County shoreline near the Richland Pumphouse. Nitrate, sulfate, and chloride concentrations were slightly elevated, compared to mid-river samples, along the Franklin County shoreline at the Richland Pumphouse transects and likely resulted from groundwater seepage associated with extensive irrigation north and east of the Columbia River. Nitrate contamination of some Franklin County groundwater has been documented by the U.S. Geological Survey (1995) and is associated with high fertilizer and water usage. Numerous wells in western Franklin County exceed the EPA maximum contaminant level for nitrate (40 CFR 141; USGS Circular 1144). Nitrate, sulfate, and chloride results were slightly higher for average quarterly concentrations at the Richland Pumphouse transect compared

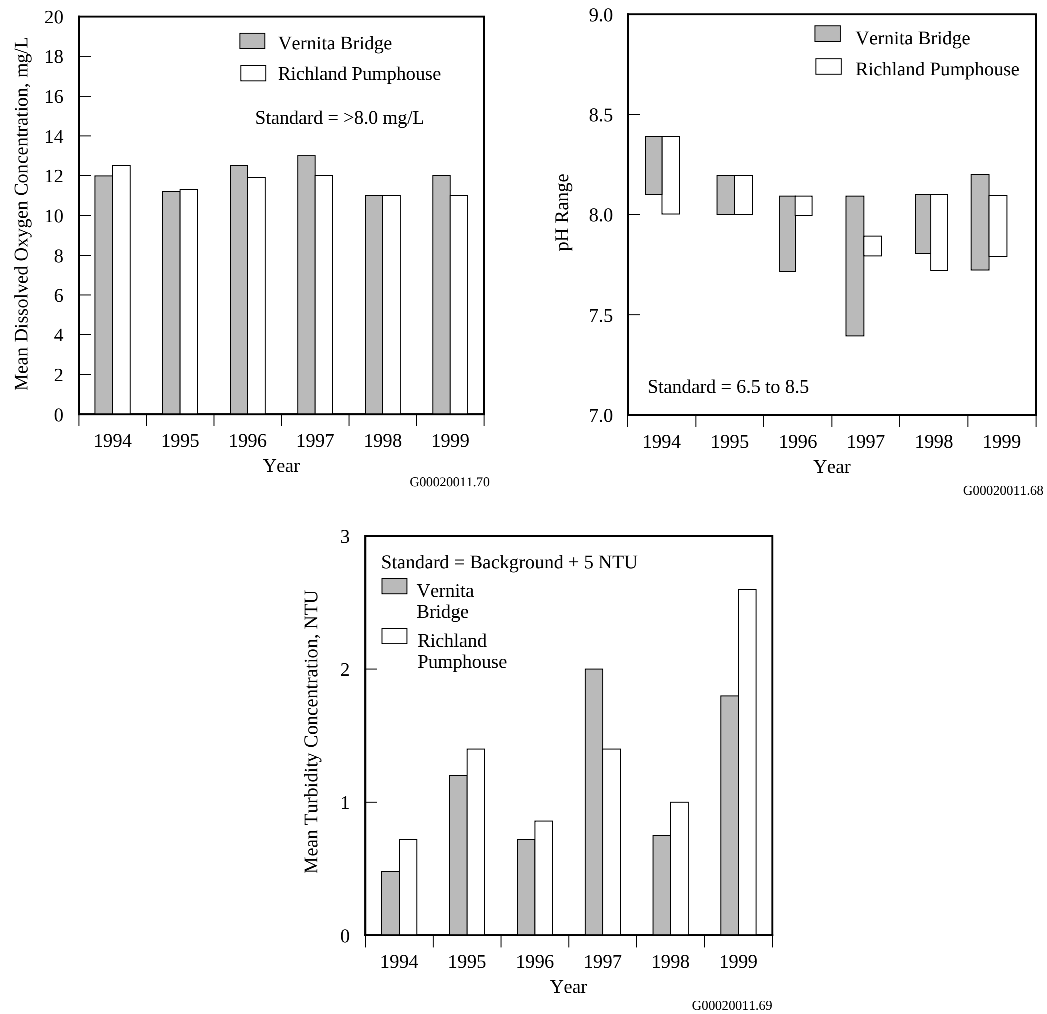

Figure 4.2.10. U.S. Geological Survey Columbia River Water Quality Measurements, 1994 Through 1999 (1999 results are preliminary; NTU = nephelometric turbidity unit)

to the Vernita Bridge transect. Nitrate, chloride, and sulfate concentrations were slightly elevated, compared to mid-river, for both shorelines at the 300 Area. Nitrate, chloride, and sulfate concentrations were slightly elevated, compared to mid-river, along the Grant County shoreline near the 100-N Area. There were no apparent concentration gradients for anions measured at Vernita Bridge, the 100-F Area, and Old Hanford Townsite transect samples.

Washington State ambient surface-water quality criteria for cadmium, copper, lead, nickel, silver, and zinc are total-hardness dependent (WAC 173-201A; see Appendix C, Table C.3). Criteria for Columbia River water were calculated using a total hardness of 47 mg/L as calcium carbonate, the limiting value based on U.S. Geological Survey monitoring of Columbia River water near Vernita Bridge and the Richland Pumphouse over the past 7 years. The total hardness reported by the U.S. Geological Survey at those locations from 1992 through 1999 ranged from 47 to 77 mg/L as calcium carbonate. All metal and anion concentrations in river water were less than the ambient surface-water quality criteria levels for both acute and chronic toxicity levels (see Appendix C, Table C.3). Arsenic concentrations exceeded EPA standards; however, similar concentrations were found at Vernita Bridge and Richland Pumphouse (see Appendix C, Table C.3).

4.2.2 Columbia River Sediment

As a result of past operations at the Hanford Site, radioactive and nonradioactive materials were discharged to the Columbia River. On release to the river, the materials were dispersed rapidly, sorbed onto detritus and inorganic particles, incorporated into aquatic biota, deposited on the riverbed as sediment, or flushed out to sea. Fluctuations in the river flow rate, as a result of the operation of hydroelectric dams, annual spring freshets, and occasional floods, have resulted in the resuspension, relocation, and subsequent redeposition of the contaminated sediments (DOE/RL-91-50, Rev. 2). Sediments in the Columbia River contain low concentrations of radionuclides and metals of Hanford Site origin as well as radionuclides from nuclear weapons testing fallout (Beasley et al. 1981, BNWL-2305, PNL-8148, PNL-10535). Potential public exposures are well below the level at which routine surveillance of Columbia River sediment is required (PNL-3127, Wells 1994). However, periodic sampling is necessary to confirm the low levels and to ensure that no significant changes have occurred for this pathway. The accumulation of radioactive materials in sediment can lead to human exposure by ingestion of aquatic species, sediment resuspension into drinking water supplies, or as an external radiation source irradiating people who are fishing, wading, sunbathing, or participating in other recreational activities associated with the river or shoreline (DOE/EH-0173T).

Since the shutdown of the last single-pass reactor in the early 1970s, the contaminant burden in the surface sediments has been decreasing as a result of radioactive decay and the subsequent deposition of uncontaminated material. However, discharges of some pollutants from the Hanford Site to the Columbia River still occur via permit-regulated liquid effluent discharges (see Section 3.1, "Facility Effluent Monitoring") and via contaminated groundwater seepage (see Section 4.2.3, "Riverbank Spring Water").

A special study was conducted in 1994 to investigate the difference in sediment grain-size composition and total organic carbon content at routine monitoring sites (PNL-10535). Physical and chemical sediment characteristics were found to be highly variable among monitoring sites along the Columbia River. Samples containing the highest percentage of silts, clays, and total organic carbon were collected above McNary Dam and from White Bluffs Slough. All other samples primarily consisted of sand. Higher contaminant burdens were generally associated with sediment containing higher total organic carbon and finer grain-size distributions.

4.2.2.1 Collection of Sediment Samples and Analytes of Interest

During 1999, samples of Columbia River surface sediment were collected at depths of 0 to 15 centimeters (0 to 6 inches) from six river locations that are permanently submerged and six riverbank springs that are periodically inundated (see Figure 4.2.1 and Table 4.2.2). Sediment sampling locations were documented using a global positioning system. In addition, sediment samples were collected behind Ice Harbor Dam on the Snake River. Samples were collected upstream of Hanford Site facilities above Priest Rapids Dam (the nearest upstream impoundment) to provide background data from an area unaffected by site operations. Samples were collected downstream of the Hanford Site above McNary Dam (the nearest downstream impoundment) to identify any increase in contaminant concentrations. Note that any increases in contaminant concentrations found in sediment above McNary Dam relative to that found above Priest Rapids Dam do not necessarily reflect a Hanford Site source. The confluences of the Columbia River with the Yakima, Snake, and Walla Walla Rivers lie between the Hanford Site and McNary Dam. Several towns, irrigation water returns, and factories in these drainages may also contribute to the contaminant load found in McNary Dam sediment; thus, sediment samples were taken at Ice Harbor Dam to assess Snake River inputs. Sediment samples were also collected along the Hanford Reach of the Columbia River from areas close to contaminant discharges (e.g., riverbank springs), from slackwater areas where fine-grained material is known to deposit (e.g., the White Bluffs, 100-F Area, Hanford Sloughs), and from the publicly accessible Richland shoreline.

Monitoring sites located at McNary and Priest Rapids Dams consisted of four stations spaced equidistant (approximately) on a transect line crossing the Columbia River, with two additional samples collected near the dams. Three stations were sampled at Ice Harbor Dam. All other monitoring sites consisted of a single sampling location. Samples of permanently inundated river sediment, herein referred to as river sediment, were collected using a grab sampler with a 235-square-centimeter (36.4-square-inch) opening. Samples of periodically inundated river sediment, herein referred to as riverbank springs sediment, were collected using a large plastic spoon, immediately following the collection of riverbank springs water samples. Sampling methods are discussed in detail in DOE/RL-91-50, Rev. 2. All sediment samples were analyzed for gamma emitters (see Appendix E), strontium-90, uranium-235, uranium-238, and metals (DOE/RL-91-50, Rev. 2). River sediment samples were also analyzed for plutonium-238, plutonium-239/240, metals, and simultaneously extracted metals/acid volatile sulfide. Sample analyses of Columbia River sediments were selected based on findings of previous Columbia River sediment investigations, reviews of past and present effluents discharged from site facilities, and reviews of contaminant concentrations observed in near-shore groundwater monitoring wells.

4.2.2.2 Radiological Results for Samples from River Sediment

Results of the radiological analyses on river sediment samples collected during 1999 are reported in PNNL-13230, APP. 1 and summarized in Appendix A (Table A.6). Radionuclides consistently detected in river sediment adjacent and downstream of the Hanford Site during 1999 included potassium-40, cobalt-60, strontium-90, cesium-137, europium-155, uranium-238, plutonium-238, and plutonium-239/240. The concentrations of all other measured radionuclides were below detection limits for most samples. Strontium-90 and plutonium-239/240 exist in worldwide fallout, as well as in effluents from Hanford Site facilities. Uranium occurs naturally in the environment in addition to being present in Hanford Site effluents. Comparisons of contaminant levels between sediment sampling locations are made below. Because of variations in the bioavailability of contaminants in various sediments, no federal or state freshwater sediment criteria are available to assess the sediment quality of the Columbia River (EPA 822-R-96-001).

Radionuclide concentrations reported in river sediment in 1999 were similar to those reported for previous years (see Appendix A, Table A.6). Median, maximum, and minimum concentrations of selected radionuclides measured in Columbia and Snake River sediments from 1994 through 1999 are presented in Figure 4.2.11. Sampling areas include stations at Priest Rapids, McNary, and Ice Harbor Dams as well as the Hanford Reach stations (White Bluffs, 100-F Area and Hanford Sloughs, and the Richland Pumphouse). Strontium-90 was the only radionuclide to exhibit consistently higher median concentrations at McNary Dam from 1994 through

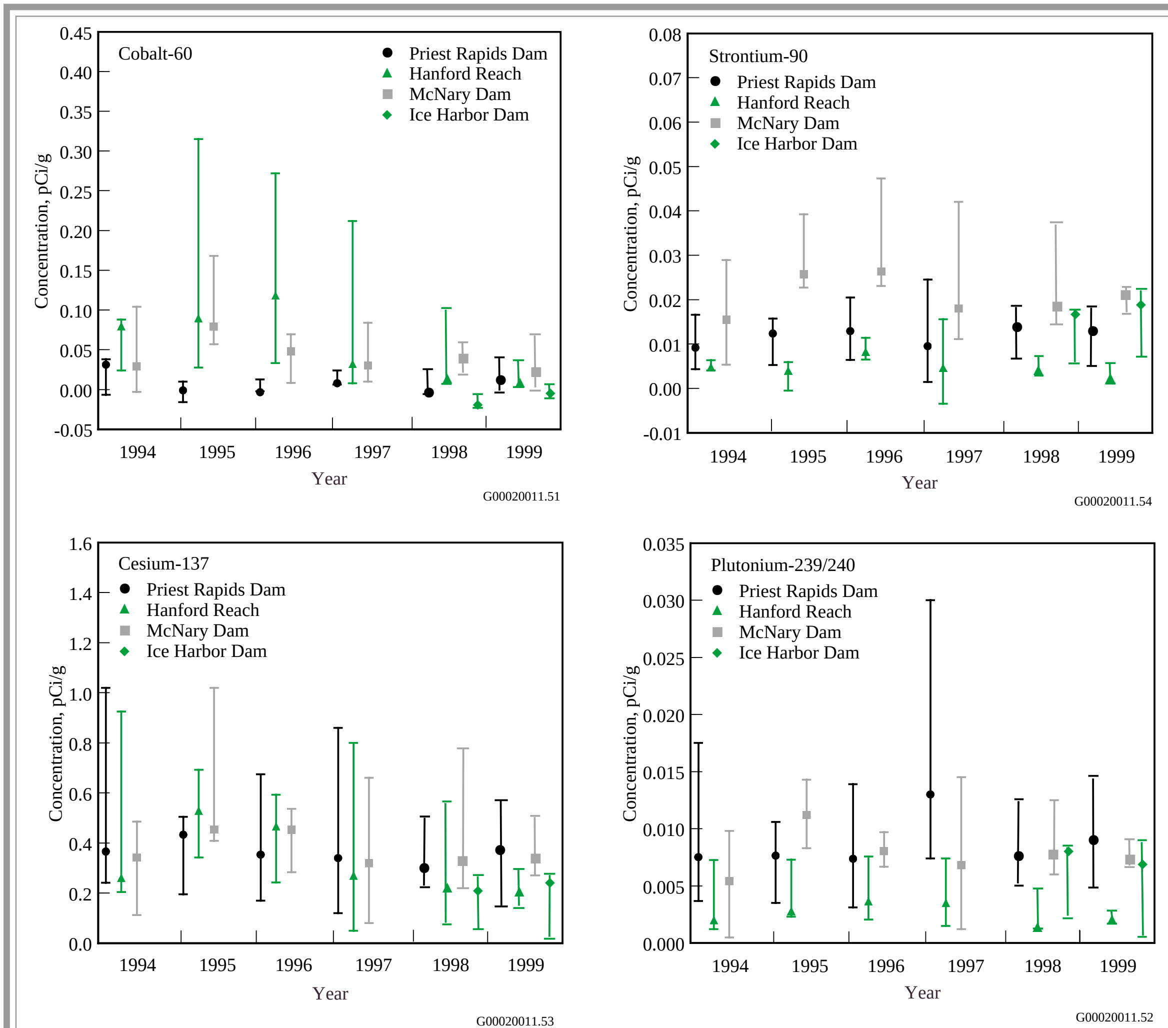

Figure 4.2.11. Median, Maximum, and Minimum Concentrations of Selected Radionuclides Measured in Columbia and Snake River Sediments, 1994 Through 1999

1999. No other radionuclides measured in 1999 exhibited appreciable differences in concentrations between locations.

4.2.2.3 Radiological Results for Sediment Samples from Riverbank Springs

Sampling of sediment from riverbank springs was begun in 1993 at the Old Hanford Townsite and 300 Area. Sampling of the riverbank springs in the 100-B, 100-F, and 100-K Areas was initiated in 1995. Sediment at all other riverbank spring sampling locations consisted of predominantly large cobble and were unsuitable for sample collection.

Radiological results for sediment collected from riverbank springs in 1999 are presented in PNNL-13230, APP. 1 and are summarized in Appendix A (Table A.6). Results were similar to those observed for previous years. In 1999, sediment samples were collected at riverbank springs in the 100-B Area, 100-F Area, Old Hanford Townsite, and 300 Area. There were no sediments available for sampling at the 100-K and 100-N Area locations. In 1999, radionuclide concentrations in riverbank spring sediment were similar to those observed in river sediment.

4.2.2.4 Nonradiological Results for Sediment Samples from the Columbia and Snake Rivers and from Riverbank Springs

Metal concentrations (total metals, reported on a dry weight basis) observed in Columbia and Snake River sediment in 1999 are reported in PNNL-13230, APP. 1 and are summarized in Appendix A (Table A.7). Detectable amounts of most metals were found in all river sediment samples (Figure 4.2.12). Metal concentrations in riverbank spring sediment samples in 1999 were similar to 1999 Columbia River sediment samples.

From 1997 to 1999, Columbia River sediments were also analyzed for simultaneously extracted metals/acid volatile sulfide (SEM/AVS). This analysis involves a cold acid extraction of the sediments followed by analysis for sulfide and metals. The SEM/AVS ratios are typically a better indicator of potential sediment toxicity than total metal concentrations (DeWitt et al. 1996, Hansen et al. 1996). Acid volatile sulfide is an important binding phase for divalent metals (i.e., metals with a valance state of 2+, such as Pb^{2+}) in sediment. Metal sulfide precipitates are typically very insoluble, and this limits the amount of dissolved metal available in the sediment porewater. For an individual metal, when the amount of acid volatile sulfide exceeds the amount of the metal (i.e., the SEM/AVS molar ratio is below 1), the metal concentration in the sediment porewater will be low because of the limited solubility of the metal sulfide. For a suite of divalent metals, the sum of the simultaneously extracted metals must be considered, with the assumption that the metal with the lowest solubility will be the first to combine with the acid volatile sulfide.

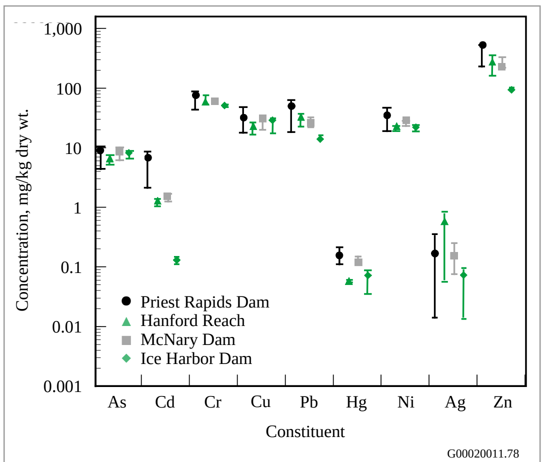

Figure 4.2.12. Median, Maximum, and Minimum Concentrations of Selected Metals Measured in Columbia and Snake River Sediments, 1999

For 1997 samples, the acid volatile sulfide results were similar for sediments from the Priest Rapids Dam reservoir and the Hanford Reach, with concentrations ranging from 1.2 to 21 μmol/g. Sediment from the McNary Dam reservoir had lower concentrations of acid volatile sulfide, with levels ranging from 0.075 to 2.6 μmol/g. When comparing the pool of available metals to the available sulfide (i.e., SEM/AVS molar ratio), sediment from both the Priest Rapid Dam and Hanford Reach should have sufficient sulfide to limit the interstitial porewater concentrations of the divalent metals tested (Figure 4.2.13a), with zinc dominating the metal concentrations. However, for the McNary Dam sediment there was more divalent metal (primarily zinc) available than the sulfide.

The SEM/AVS results for the 1998 samples were similar to 1997 (Figure 4.2.13b), with the exception of the average acid volatile sulfide concentration for Priest Rapid Dam sediment that decreased by a factor of two. For 1998, the acid volatile sulfide values were similar for sediments from the Priest Rapid Dam reservoir and the Hanford Reach, with concentrations ranging from 0.32 to 15 μmol/g. Sediments from the McNary Dam reservoir and the Ice Harbor

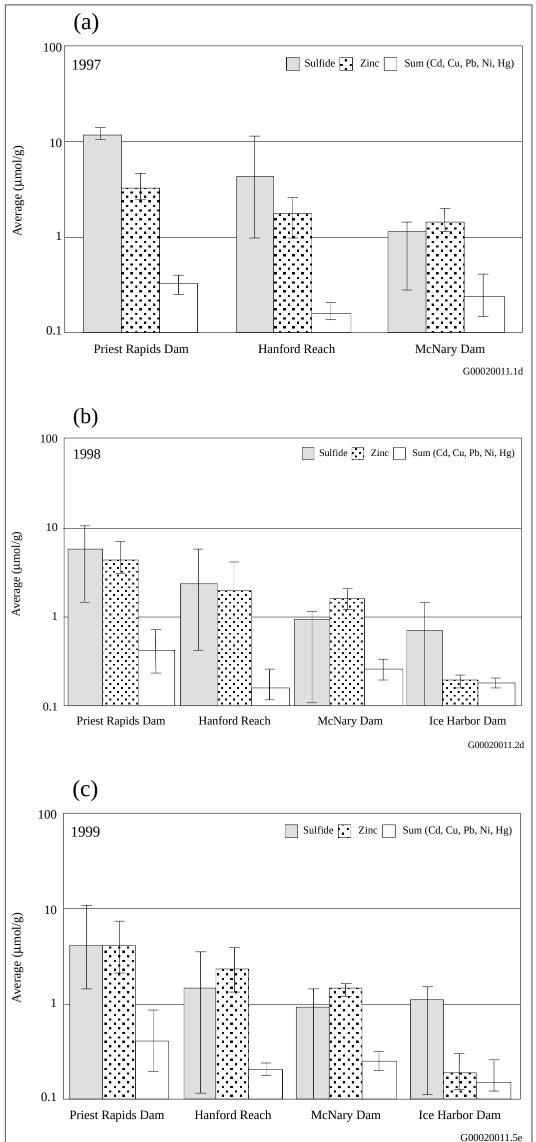

Figure 4.2.13. Average Acid Volatile Sulfide, Simultaneously Extracted Zinc, and Sum of Simultaneously Extracted Metals in Columbia River and Snake River (Ice Harbor Dam) Sediments for 1997 (a), 1998 (b), and 1999 (c) (±1 standard deviation)

Dam reservoir (Snake River) had lower concentrations of acid volatile sulfide, with values ranging from 0.033 to 2.4 µmol/g. For 1998, the SEM/AVS molar ratios were close to one for Priest Rapids Dam and Hanford Reach sediments, with zinc as the dominant metal. For 1998, the SEM/AVS molar ratios for sediment from McNary Dam were above one, indicating a potential for some metals to be present in the sediment porewater, with zinc as the primary metal present. Ice Harbor Dam sediment had similar concentrations of acid volatile sulfide as McNary Dam; however, the zinc concentrations for Ice Harbor Dam sediment were an order of magnitude below the Columbia River sediments.

The SEM/AVS results for the 1999 samples were similar to 1998 (Figure 4.2.13c). For 1999, the acid volatile sulfide values were similar for sediment from the Priest Rapid Dam reservoir and the Hanford Reach, with concentrations ranging from 0.33 to 14 µmol/g. Sediment from the McNary Dam reservoir and the Ice Harbor Dam reservoir (Snake River) had lower concentrations of acid volatile sulfide, with values ranging from 0.081 to 3.2 µmol/g. For 1999, the SEM/AVS molar ratios were close to one for Priest Rapids Dam and above one for Hanford Reach sediments, with zinc as the dominant metal. For 1999, the SEM/AVS molar ratios for sediment from McNary Dam were above one, indicating a potential for some metals to be present in the sediment porewater, with zinc as the primary metal present. Ice Harbor Dam sediment had similar concentrations of acid volatile sulfide as McNary Dam; however, the average zinc concentrations for Ice Harbor Dam sediments were five times below the Columbia River sediments.

These results reveal an apparent difference in the acid volatile sulfide concentrations in sediment from Priest Rapids Dam reservoir and the Hanford Reach, which have higher concentrations than McNary Dam and Ice Harbor Dam sediment. An apportionment of acid volatile sulfide by divalent metals according to solubility values revealed that sufficient acid volatile sulfide should exist in all locations to limit the porewater concentrations of cadmium, copper, lead, and mercury. For Priest Rapids Dam, Hanford Reach, and Ice Harbor Dam sediments, zinc values were of similar magnitude as the acid volatile sulfide concentrations. For McNary

Dam sediment, the zinc concentrations were higher than the available acid volatile sulfide pool, indicating the potential for nickel and zinc (the two most soluble of the metals tested) to be bioavailable in the sediment porewater.

4.2.3 Riverbank Spring Water

The Columbia River is the primary discharge area for the unconfined aquifer underlying the Hanford Site (see Section 6.1.2, "Groundwater Hydrology). Groundwater provides a means for transporting Hanford-associated contaminants, which have leached into groundwater from past waste disposal practices, to the Columbia River (DOE/RL-92-12, PNL-5289, PNL-7500, WHC-SD-EN-TI-006). Contaminated groundwater enters the Columbia River via surface and subsurface discharge. Discharge zones located above the water level of the river are identified in this report as riverbank springs. Routine monitoring of riverbank springs offers the opportunity to characterize the quality of groundwater being discharged to the river and to assess the potential human and ecological risk associated with the spring water.

The seepage of groundwater into the Columbia River has occurred for many years. Riverbank springs were documented along the Hanford Reach long before Hanford Site operations began during World War II (Jenkins 1922). In the early 1980s, researchers walked the 66-kilometer (41-mile) stretch of Benton County shoreline of the Hanford Reach and identified 115 springs (PNL-5289). They reported that the predominant areas of groundwater discharge at that time were in the vicinity of the 100-N Area, Old Hanford Townsite, and 300 Area. The predominance of the 100-N Area may no longer be valid because of declining water-table elevations in response to the decrease in liquid waste discharges to the ground from Hanford Site operations. In recent years, it has become increasingly difficult to locate riverbank springs in the 100-N Area.

The presence of riverbank springs also varies with river stage. Groundwater levels in the 100 and 300 Areas are heavily influenced by river stage fluctuations (see Section 6.1, "Hanford Groundwater Monitoring Project"). Water levels in the Columbia River fluctuate greatly on annual and even daily cycles and are controlled by the operation of Priest Rapids Dam upstream of the site. Water flows into the aquifer (as bank storage) as the river stage rises and flows in the opposite direction as the river stage falls. Following an extended period of low river discharge, groundwater discharge zones located above the water level of the river may cease to exist once the level of the groundwater comes into equilibrium with the level of the river. Thus, springs are most readily identified immediately following a decline in river stage. Bank storage of river water also affects the contaminant concentration of the springs. Spring water discharge immediately following a river stage decline generally consists of river water or a river/groundwater mix. The percentage of groundwater in the spring water discharge is believed to increase over time following a drop in river stage.

Because of the effect of bank storage on groundwater discharge and contaminant concentration, it is difficult to estimate the volume of contaminated groundwater discharged to the Columbia River within the Hanford Reach. The estimated total groundwater discharge from the upstream end of the 100 Areas to south of the 300 Area is ~66,500 m^3 (2,350,000 ft^3) per day.[(a)] This represents only 0.02% of the long-term average flow rate of the Columbia River, which illustrates the tremendous dilution potential afforded by the river. It should be noted

(a) Stuart Luttrell. January 1995. Personal communication with author, G. W. Patton, Pacific Northwest National Laboratory, Richland, Washington.

that not all of the groundwater discharged to the river contains contaminants originating from Hanford Site operations. Studies of riverbank springs conducted in 1983 (PNL-5289) and in 1988 (PNL-7500) and a near-shore study (PNNL-11933) noted that discharges from the springs had a localized effect on river contaminant concentrations. Both studies reported that the volume of groundwater entering the river at these locations was very small relative to the flow of the river and that the impact of groundwater discharges to the river was minimal.

4.2.3.1 Collection of Water Samples from Riverbank Springs and Analytes of Interest

Routine monitoring of selected riverbank springs was initiated in 1988 at the 100-N Area, Old Hanford Townsite, and 300 Area. Monitoring was expanded in 1993 to include riverbank springs in the 100-B, 100-D, 100-H, and 100-K Areas. A riverbank spring located at 100-F Area was added in 1994. The locations of all riverbank springs sampled in 1999 are identified in Figure 4.2.1. Sample collection methods are described in DOE/RL-91-50, Rev. 2. Analytes of interest for samples from riverbank springs were selected based on findings of previous investigations, reviews of contaminant concentrations observed in nearby groundwater monitoring wells, and results of preliminary risk assessments. Sampling is conducted annually when river flows are low, typically in late summer/fall.

Samples of water from riverbank springs were collected in October and November 1999. All samples collected during 1999 were analyzed for gamma-emitting radionuclides, gross alpha, gross beta, and tritium. Samples from selected springs were analyzed for strontium-90, technetium-99, iodine-129, and uranium-234, -235, and -238. All samples were analyzed for metals and anions, with volatile organic compounds analyzed at selected locations. All analyses were conducted on unfiltered samples, except for metals which were analyzed for both filtered and unfiltered samples.

Hanford-origin contaminants continued to be detected in water from riverbank springs entering the Columbia River along the Hanford Site during 1999. The locations and extent of contaminated discharges were consistent with recent groundwater surveys. Tritium, strontium-90, technetium-99, iodine-129, uranium-234, -235, and -238, metals (antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, thallium, zinc, and occasionally silver), and anions (chloride, fluoride, nitrate, and sulfate) were detected in springs water. Volatile organic compounds were near or below the detection limits for all samples. The contaminant concentrations in water from riverbank springs are typically lower than those found in near-shore groundwater wells because of bank storage effects.

Results of radiological and chemical analyses conducted on samples from riverbank springs in 1999 are documented in PNNL-13230, APP. 1. Radiological results obtained in 1999 are summarized in Appendix A (Table A.8) and compared to those reported in 1994 through 1998. In the following discussion, radiological and nonradiological results are addressed separately. Contaminant concentration trends are illustrated for selected locations.

4.2.3.2 Radiological Results for Water Samples from Riverbank Springs

All radiological contaminant concentrations measured in riverbank springs in 1999 were less than the DOE derived concentration guides (DOE Order 5400.5; see Appendix C, Table C.5). However, the spring at the 100-N Area that has historically exceeded the DOE derived concentration guide for strontium-90 was not flowing during 1998 and 1999 sample collection; thus, an alternative spring was sampled in the 100-N Area. Tritium concentrations in water from riverbank springs at the Old Hanford Townsite exceeded the ambient surface-water quality criteria levels (WAC 173-201A and 40 CFR 141) and the 100-B (38-3) riverbank spring water was at the criteria level. Tritium concentrations in riverbank spring water at the 100-N and 300 Areas were greater than 50% of the ambient surface water criteria level (WAC 173-201A and 40 CFR 141). Strontium-90 concentration in riverbank spring water was above the ambient surface water criteria level at the 100-H Area (spring 153-1) and was greater than 50% of the criteria level at the 100-B Area (spring 39-2). There are no ambient surface-water quality criteria levels directly applicable to uranium. However, total uranium concentrations exceeded the site-specific proposed EPA drinking water standard (EPA 822-R-96-001) in the 300 Area (see Appendix C, Table C.2). The gross alpha concentration exceeded the ambient surface-water quality criteria level in riverbank spring water at the 300 Area, which is consistent with the elevated uranium levels. All other radionuclide concentrations in 300 Area springs water were less than ambient surface-water quality criteria levels. Gross beta concentrations in riverbank spring water at the Old Hanford Townsite and the 300 Area were near the surface-water quality criteria level.

Tritium concentrations varied widely with location. The highest tritium concentration detected in riverbank springs water was at the Old Hanford Townsite (110,000 ± 4,100 pCi/L), followed by the 100-B Area (20,000 ± 870 pCi/L), 100-N Area (14,000 ± 670 pCi/L), and 300 Area (11,000 ± 570 pCi/L). The ambient surface-water quality criteria level for tritium is 20,000 pCi/L. Tritium concentrations in all riverbank springs water samples were elevated compared to the 1999 average Columbia River level at Priest Rapids Dam (37 ± 5.0 pCi/L).

Samples from riverbank springs in the 100-H Area and Old Hanford Townsite were analyzed for technetium-99. The highest technetium-99 concentration was found in water from the Old Hanford Townsite spring (120 ± 8.0 pCi/L), in agreement with the observed beta concentrations.

Samples from riverbank springs at the Old Hanford Townsite and 300 Area were analyzed for iodine-129. The highest concentration was measured in a water sample from the Old Hanford Townsite spring (0.41 ± 0.024 pCi/L). This value was elevated compared to the 1999 average measured at Priest Rapids Dam (0.0000047 ± 0.0000013 pCi/L) but was below the 1-pCi/L surface-water quality criteria level (see Appendix C, Table C.2).

Uranium was sampled in riverbank spring water in the 100-H Area, 100-F Area, Old Hanford Townsite, and 300 Area in 1999. The highest level was found in 300 Area spring water (210 ± 38 pCi/L), which was collected from a spring located downgradient from the retired 300 Area process trenches. The 300 Area spring had elevated gross alpha concentration, which paralleled that of uranium.

Samples from riverbank springs were analyzed for strontium-90 in the 100-B, 100-D, 100-F, 100-H, 100-K, 100-N Areas, and 300 Area. The highest strontium-90 concentration detected in riverbank spring water was at the 100-H Area (14 ± 3.1 pCi/L) and this value exceeded the ambient surface water quality criteria of 8 pCi/L. The strontium-90 concentration in riverbank spring water from the 100-B Area was 57% of the ambient surface water quality criteria.

Historically, riverbank seepage in the 100-N Area has been monitored for contaminants by sampling from well 199-N-8T, which is located close to the river; well 199-N-46 (caisson), which is slightly inland from well 199-N-8T (PNNL-11795, Figure 3.2.4); or riverbank springs. Since 1993, 100-N Area seepage samples for the Surface Environmental Surveillance Project have been collected only from riverbank springs. The Near-Facility Environmental Monitoring program (see Section 3.2.2, "Surface-Water Disposal Units and 100-N Area Riverbank Springs Monitoring") also collects water samples along the 100-N shoreline at monitoring well 199-N-46 and at shoreline seepage wells. The Near-Facility Environmental Monitoring program reported 1999 strontium-90 concentrations exceeded the 1,000 pCi/L derived concentration guide for a shoreline seepage well near monitoring well 199-N-46 (see Table 3.2.4). For 1993 to 1996, 1998, and 1999 there were no visible riverbank springs directly adjacent to wells 199-N-8T or 199-N-46 during the sampling period. The 100-N Area riverbank springs samples were, therefore, collected from the nearest visible downstream riverbank spring.

In 1999, samples were collected from the same downstream riverbank spring sampled in previous years (i.e., downriver from well 199-N-8T). Contaminant activities measured in the water from the two riverbank springs locations sampled in previous years were distinctly different (Table 4.2.3). Historically, the concentrations of strontium-90 and gross beta were considerably higher in the riverbank spring directly adjacent to well 199-N-8T than for the downstream spring. Tritium levels in water from riverbank springs are typically elevated at both locations, and the 1999 tritium result was similar to those found in previous years (see Table 3.2.5). Tritium was the only contaminant detected at the 100-N Area riverbank spring in 1999. The tritium concentration was 70% of the ambient surface-water quality criteria level (see Appendix C, Table C.2). The tritium results for the samples from 100-N Area riverbank springs are of the same magnitude as those reported in Section 3.2, "Near-Facility Environmental Monitoring," Table 3.2.7.

Concentrations of selected radionuclides in riverbank spring water near the Old Hanford Townsite (spring 28-2) from 1994 through 1999 are provided in Figure 4.2.14. Gross beta and technetium-99 concentrations show an increasing trend since 1994. The 1999 tritium and iodine-129 concentrations were similar to those in recent years. Annual fluctuations in these values may reflect the influence of bank storage during the sampling period. The maximum tritium and technetium-99 levels detected in water from Old Hanford Townsite riverbank springs in 1999 were 550% and 413% of their respective ambient surface-water quality criteria levels (see Appendix C, Table C.2). The maximum iodine-129

Table 4.2.3. Selected Radionuclide Concentrations in 100-N Area Riverbank Spring Water, 1994 Through 1999

	Concentration, pCi/L[(a)]		
Year	**Tritium**	**Gross Beta**	**Strontium-90**
1994[(b)]	31,000 ± 2,400	8.8 ± 2.3	0.13 ± 0.11
1995[(b)]	12,000 ± 970	1.5 ± 1.5	0.079 ± 0.10
1996[(b)]	17,000 ± 1,300	4.5 ± 1.8	0.053 ± 0.048
1997[(b)]	19,000 ± 1,500	3.5 ± 1.6	0.59 ± 0.13
1997[(c)]	14,000 ± 1,100	16,000 ± 1,400	9,900 ± 1,800
1998[(b)]	24,000 ± 1,900	2.3 ± 2.1	[(d)]
1999[(b)]	14,000 ± 670	2.9 ± 1.7	0.026 ± 0.034

(a) Concentrations are ±2 total propagated analytical uncertainty.
(b) Sample collected from riverbank spring downstream of well 199-N-8T.
(c) Samples collected from spring below well 199-N-8T (100-N Area spring 8-13, see PNNL-11795, Figure 3.2.4).
(d) Sample was lost during processing at the analytical laboratory.

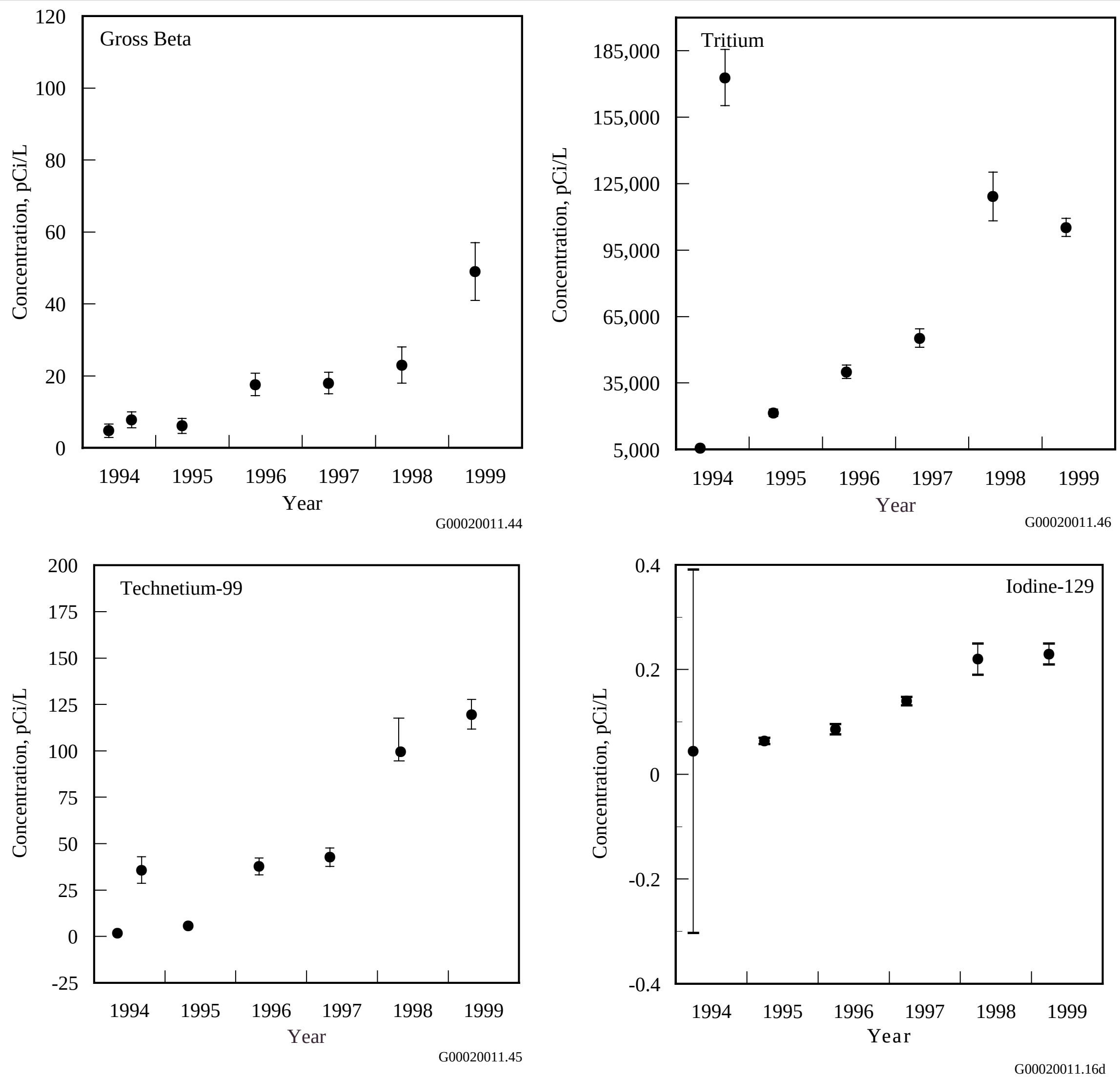

Figure 4.2.14. Concentrations (results ±2 total propagated analytical uncertainty) of Constituents of Interest in Columbia River Riverbank Spring Water at the Old Hanford Townsite, 1994 Through 1999. As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.

concentration measured in water from the Old Hanford Townsite riverbank springs for 1999 was 41% of the ambient surface-water quality criteria level (see Appendix C, Table C.2).

Figure 4.2.15 depicts the concentrations of selected radionuclides in the 300 Area riverbank springs from 1994 through 1999. Results in 1999 were similar to those observed previously, except for gross beta which was elevated. The elevated tritium levels measured in the 300 Area riverbank springs are indicators of the contaminated groundwater plume from the 200 Areas (Section 5.9 in PNL-10698). In addition, iodine-129 is also contained in the 200 Areas' contaminated groundwater plume. The maximum tritium and iodine-129 concentrations in water from 300 Area riverbank springs in 1999 were 57% and 0.06% of their respective ambient surface-water quality criteria levels (see Appendix C, Table C.2). The highest total uranium levels in riverbank

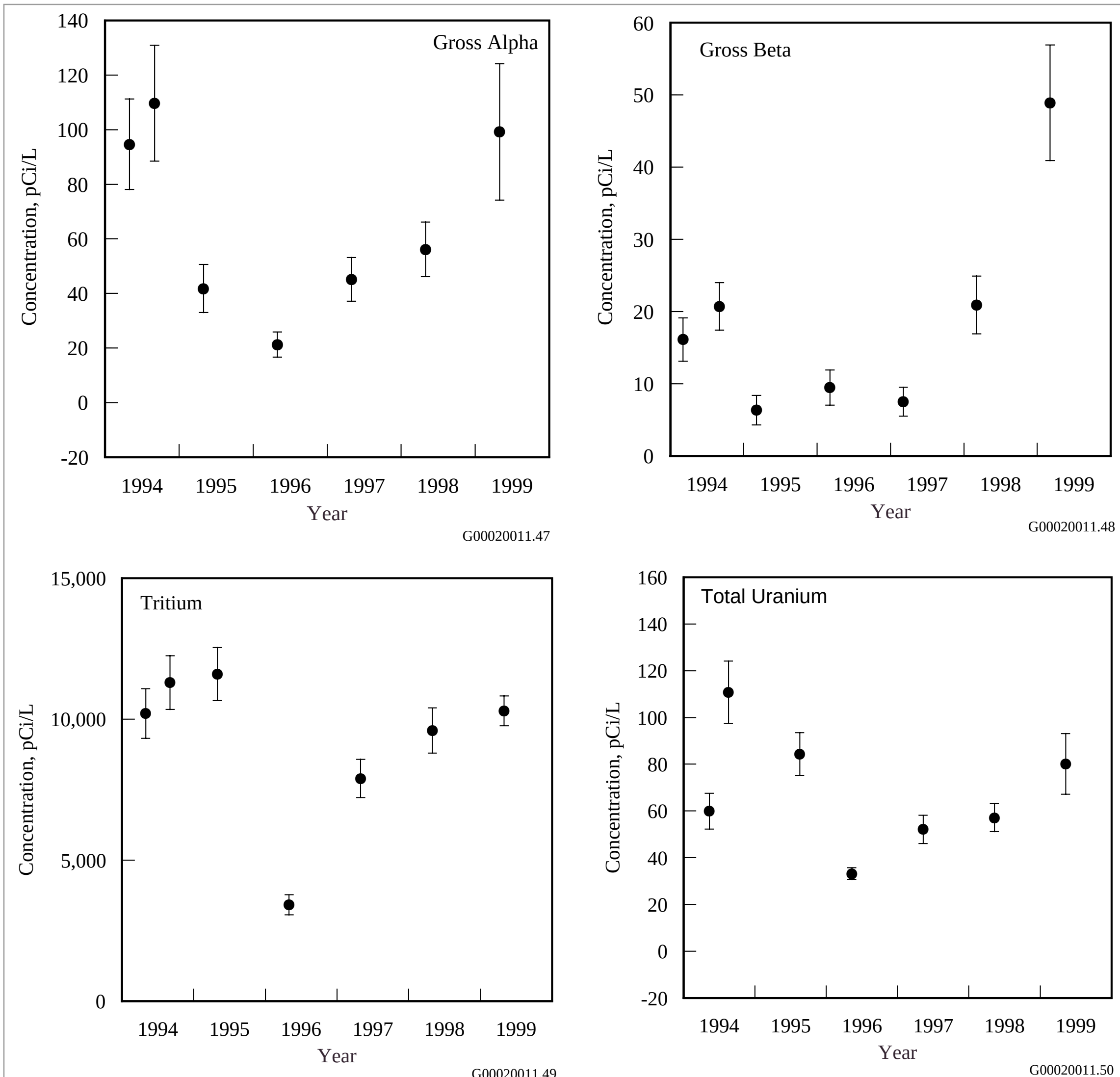

Figure 4.2.15. Concentrations (results ±2 total propagated analytical uncertainty) of Constituents of Interest in Water from a Columbia River Riverbank Spring Near the 300 Area (Spring 42-2), 1994 Through 1999

spring water from 1994 through 1999 were found in the 300 Area riverbank springs. The 1999 maximum total uranium value was more than 15 times higher than the proposed site-specific EPA drinking water standard (13.4 pCi/L [EPA 822-R-96-001]; see Appendix C, Table C.2). Elevated uranium concentrations exist in the unconfined aquifer beneath the 300 Area in the vicinity of uranium fuel fabrication facilities and inactive waste sites. The gross alpha and gross beta concentrations in the 300 Area riverbank springs water from 1994 through 1999 parallel uranium and are likely associated with its presence.

4.2.3.3 Nonradiological Results for Water Samples from Riverbank Springs

Concentration ranges of selected chemicals measured in riverbank springs water in 1994 through 1999 are presented in Table 4.2.4. For most

Table 4.2.4. Concentration Ranges for Selected Chemicals in Water from Columbia River Riverbank Springs, 1997 Through 1999

	Ambient Surface-Water Quality Criteria Level, µg/L[a,b]	Concentration, µg/L							
		100-B Area	100-K Area	100-N Area	100-D Area	100-H Area	100-F Area	Old Hanford Townsite	300 Area
No. of Samples		4	3	4	4	4	3	5	4
Antimony	--	0.064 - 0.24	0.17 - 0.42	0.15 - 0.27	0.12 - 0.36	0.20 - 0.31	0.099 - 0.17	0.098 - 0.42	0.14 - 0.28
Arsenic	190	0.91 - 1.3	1.2 - 1.5	0.83 - 3.2	0.67 - 1.4	0.90 - 2.1	2.0 - 2.8	3.2 - 4.9	1.1 - 8.2
Cadmium	0.64[c]	0.010 - 0.033	0.010 - 0.067	0.014 - 0.072	0.02 - 0.088	0.03 - 0.087	0.032 - 0.10	0.01 - 0.1	0.010 - 1.6
Chromium	11	13 - 20	1.7 - 66	4.1 - 8.9	24 - 330	17 - 120	9.3 - 22	2.0 - 5.3	2.7 - 24
Copper	6.3[c]	0.36 - 4.9	0.33 - 1.1	0.32 - 0.79	0.51 - 1.5	0.53 - 2.9	0.88 - 1.5	0.46 - 1.2	0.74 - 32
Lead	1.2[c]	0.33 - 0.9	0.056 - 2.5	0.11 - 0.76	0.044 - 0.77	0.20 - 5.8	0.53 - 1.9	0.18 - 1.6	0.25 - 37
Nickel	85[c]	0.62 - 2.0	0.83 - 1.6	0.78 - 1.6	0.74 - 1.7	0.87 - 2.1	1.2 - 2.9	0.71 - 2.1	0.73 - 32
Selenium	5	1.2 - 2.9	0.55 - 2.2	0.55 - 1.1	0.67 - 2.3	0.55 - 0.96	0.55 - 3.0	1.6 - 2.4	1.8 - 3.9
Silver	1.2[c] acute	0.0080 - 0.015	0.0080 - 0.013	0.008 - 0.013	0.008 - 0.016	0.0080 - 0.013	0.0080 - 0.029	0.008 - 0.068	0.0080 - 0.14
Thallium	--	0.0040 - 0.014	0.012 - 0.047	0.011 - 0.054	0.025 - 0.098	0.0081 - 0.055	0.011 - 0.025	0.012 - 0.035	0.014 - 0.41
Zinc	57[c]	0.70 - 5.4	1.3 - 4.7	1.2 - 4.4	1.3 - 10	1.3 - 32	4.1 - 12	0.66 - 110	4.0 - 230
Nitrate		1.8 - 4.0	0.32 - 6.6	3.1 - 4.8[d]	0.84 - 9.4	1.2 - 10	8.8 - 12	1.8 - 8.1	4.0 - 6.5
No. of Samples		3	1	1	3	3	2	4	3
Mercury	0.012	0.00066 - 0.0013	0.00086	0.00051	0.00086 - 0.0025	0.00065 - 0.0015	0.0015 - 0.0017	0.00056 - 0.0026	0.00096 - 0.035
No. of Samples		4	3	4	4	4	3	5	4
Conductivity (µS/cm)	--	253 - 363	164 - 378	228 - 359	149 - 271	190 - 516	341 - 505	285 - 408	334 - 455

(a) WAC 173-201A-040.
(b) Levels that result in chronic toxicity, unless otherwise noted.
(c) Ambient surface-water quality criteria level is hardness-dependent; listed value assumes a hardness of 48 mg $CaCO_3$/L.
(d) n=3.

locations, the 1999 nonradiological sample results were similar to those reported previously (PNNL-12088). Nitrate concentrations were highest in the 100-F Area. Chromium concentrations are typically highest in the 100-D, 100-H, and 100-K Areas' riverbank springs. Hanford groundwater monitoring results for 1999 indicated similar nonradiological contaminants in shoreline areas (see Section 6.1, "Hanford Groundwater Monitoring Project").

The ambient surface-water quality criteria for cadmium, copper, lead, nickel, silver, and zinc are total-hardness dependent (WAC 173-201A; see Appendix C, Table C.3). For comparison purposes, spring water criteria were calculated using the same 48-mg calcium carbonate per liter hardness given in Appendix C, Table C.3. Most metal concentrations measured in water from riverbank springs collected from the Hanford Site shoreline in 1999 were below ambient surface-water acute toxicity levels (WAC 173-201A). However, concentrations of chromium in 100-B, 100-K, 100-D, 100-H, 100-F, and 300 Areas spring water, and copper, lead, and zinc concentrations in 300 Area spring water were above ambient surface water acute toxicity levels (see Appendix C, Table C.3). Arsenic concentrations in riverbank spring water were well below ambient surface water chronic toxicity levels, but all samples (including upriver Columbia River water samples) exceeded the federal limit (40 CFR 141, see Appendix C, Table C.3). Riverbank spring water was above the ambient surface water chronic toxicity levels for cadmium and mercury at the 300 Area and lead at the 100-H Area and the Old Hanford Townsite. Nitrate concentrations at all spring water locations were below the drinking water standard (see Appendix C, Table C.2).

4.2.4 Onsite Pond Water

Two onsite ponds (see Figure 4.2.1), located near operational areas, were sampled periodically during 1999. The ponds are inaccessible to the public and, therefore, did not constitute a direct offsite environmental impact during 1999. However, they were accessible to migratory waterfowl, creating a potential biological pathway for the dispersion of contaminants (PNL-10174). The Fast Flux Test Facility pond is a disposal site for process water (primarily cooling tower water). West Lake, the only naturally occurring pond on the site, is located north of the 200-East Area (ARH-CD-775). West Lake has not received direct effluent discharges from Hanford Site facilities but is influenced by changing water-table elevation as a result of previous discharge of water to the ground in the 200 Areas.

4.2.4.1 Collection of Pond Water Samples and Analytes of Interest

In 1999, grab samples were collected quarterly from the Fast Flux Test Facility Pond and from West Lake. Unfiltered aliquots of all samples were analyzed for gross alpha and gross beta concentrations, gamma-emitting radionuclides, and tritium. West Lake samples were also analyzed for strontium-90 (April 6, 1999 only), technetium-99, and uranium-234, -235, and -238. Constituents were chosen for analysis based on their known presence in local groundwater or in effluents discharged to the pond and their potential to contribute to the overall radiation dose to the public.

4.2.4.2 Radiological Results for Pond Water Samples

Analytical results from pond water samples collected during 1999 are reported in PNNL-13230, APP. 1. With the exceptions of uranium-234 and uranium-238 in the April and July samples from West Lake, radionuclide concentrations in onsite pond water were less than the DOE derived concentration guides (DOE Order 5400.5; see Appendix C, Table C.5). The median gross alpha, gross beta, and total uranium concentrations exceeded their ambient surface-water quality criteria in West Lake. The median concentrations of all other radionuclides were below ambient surface-water quality criteria levels (WAC 173-201A, 40 CFR 141; see Appendix C, Table C.2).

Figure 4.2.16 shows the annual gross beta and tritium concentrations in Fast Flux Test Facility Pond water from 1994 through 1999. Median levels of both constituents have remained stable in recent years. However, the tritium concentration in the July 1995 sample was 16,400 pCi/L, which was much higher than that observed previously. The use of well 499-S0-7 during this time is most likely responsible for the high levels of tritium observed in July 1995. Tritium levels in well 499-S0-7 are typically greater than 20,000 pCi/L, reflective of those observed in a portion of the local unconfined aquifer. Median gross beta and tritium concentrations in Fast Flux Test Facility Pond water during 1999 were 26% and 21% of their respective ambient surface-water quality criteria. The concentrations of all other measured contaminants in this pond water were below detection limits, except for naturally occurring potassium-40.

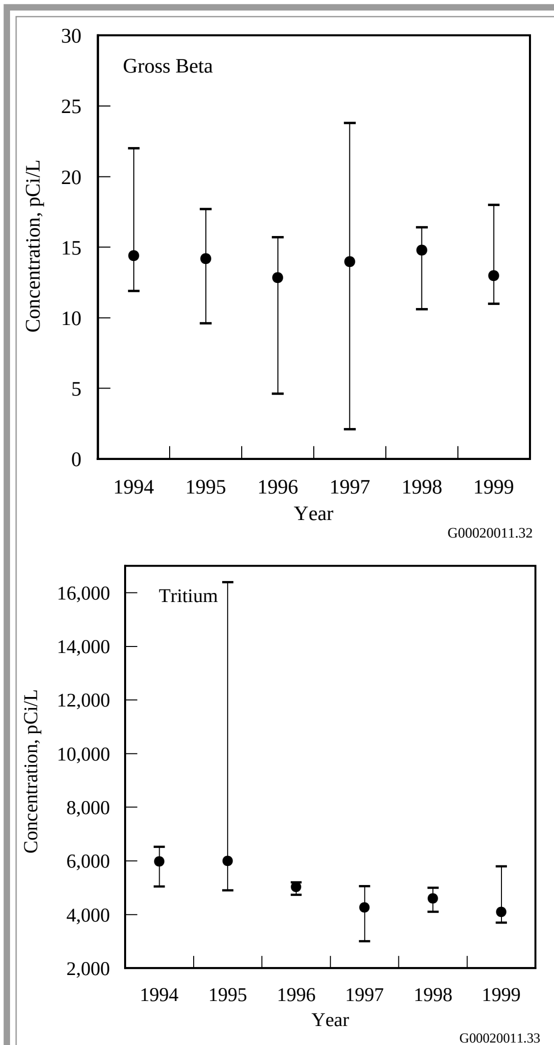

Figure 4.2.16. Median, Maximum, and Minimum Gross Beta and Tritium Concentrations in Fast Flux Test Facility Pond Water Samples, 1994 Through 1999

The annual concentrations of selected radionuclides from 1994 through 1999 in West Lake water are shown in Figure 4.2.17. Median radionuclide concentrations in West Lake during 1999 were similar to those observed in the past. The gross alpha and gross beta levels in West Lake water are believed to result from high levels of naturally occurring uranium in the surrounding soil (BNWL-1979, PNL-7662). Annual median total uranium concentrations have remained stable over the last 6 years, but the range is large. The highest concentrations measured in 1999 were in the summer, when the water level in the pond was low. It is thought that the relatively large concentration of suspended sediment in the samples is causing the elevated results. Similar total uranium levels were reported in PNNL-7662 for West Lake samples that contained high concentrations of suspended sediment. Declines in groundwater levels beneath the 200 Areas have been recorded since the decommissioning of the 216-U-10 pond in 1984 and the shutdown of production facilities (see Section 6.1, "Hanford Groundwater Monitoring Project"). As a result, the water level in West Lake has dropped. Median concentrations of tritium, strontium-90, and technetium-99 in West Lake in 1999 were 0.33%, 22%, and 16%, respectively, of the ambient surface-water quality criteria levels and reflected local groundwater concentrations. The concentrations of all other measured radionuclides were below their detection limits, except for naturally occurring potassium-40.

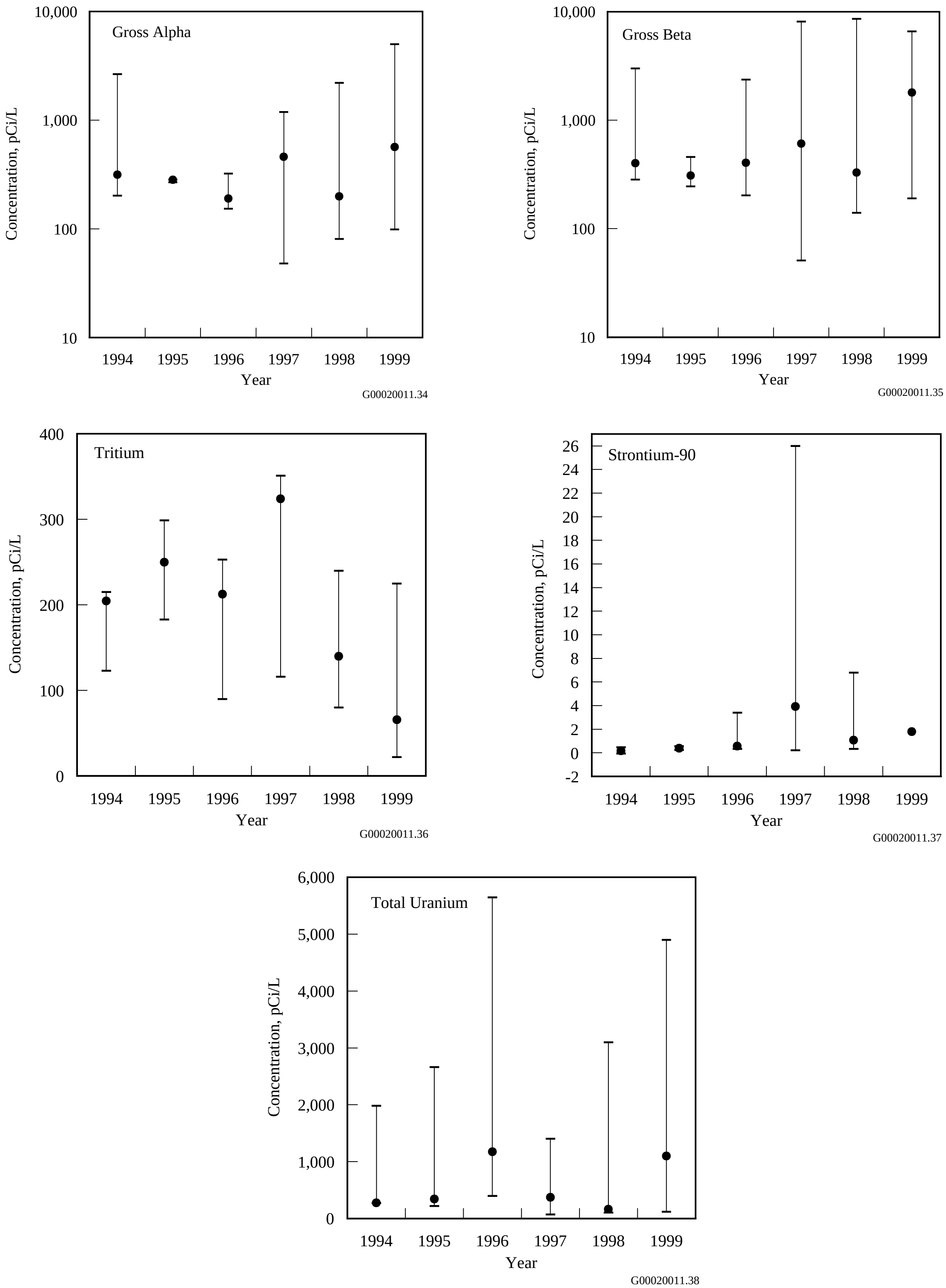

Figure 4.2.17. Median, Maximum, and Minimum Concentrations of Selected Radionuclides in West Lake Water Samples, 1994 Through 1999

4.2.5 Offsite Water

During 1999, water samples were collected from an irrigation canal across the Columbia River and downstream from the Hanford Site that receives water pumped from the Columbia River near Pasco, Washington. As a result of public concern about the potential for Hanford-associated contaminants in offsite water, sampling was conducted to document the levels of radionuclides in water used by the public. Consumption of vegetation irrigated with Columbia River water downstream of the site has been identified as one of the primary pathways contributing to the potential dose to the hypothetical maximally exposed individual and any other member of the public (see Section 5.0, "Potential Radiological Doses from 1999 Hanford Operations").

4.2.5.1 Collection, Analysis, and Results for Irrigation Canal Water

Water in the Riverview irrigation canal was sampled three times in 1999 during the irrigation season. Unfiltered samples of the canal water were analyzed for gross alpha, gross beta, gamma emitters, tritium, strontium-90, and uranium-234, -235, and -238. Results are presented in PNNL-13230, APP. 1. In 1999, radionuclide concentrations measured in this canal's water were at the same levels detected in the Columbia River. All radionuclide concentrations were below the DOE derived concentration guides and ambient surface-water quality criteria levels (DOE Order 5400.5, WAC 173-201A, 40 CFR 141). The strontium-90 levels in the irrigation water during 1999 ranged from 0.051 ± 0.032 to 0.066 ± 0.029 pCi/L and were similar to those reported for the Columbia River at Priest Rapids Dam and the Richland Pumphouse (see Section 4.2.1, "Columbia River Water").